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WATER RESOURCES STUDY, COOPER RESERVOIR, SOUTH SULPHUR RIVER, TEXAS

Public Health Service
Dallas, Texas

July 1963

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WATER RESOURCES STUDY

COOPER RESERVOIR

SOUTH SULPHUR RIVER

TEXAS

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Division of Water Supply and Pollution Control
Dallas, Texas

In Cooperation with the

DEPARTMENT OF THE ARMY
U.S. Army Engineer District--New Orleans, Louisiana

JULY 1963

TABLE OF CONTENTS

		Page
LIST OF TABLES		iii
LIST OF FIGURES		iv
I.	INTRODUCTION	
	Authority	I-1
	Purpose and Scope	I-1
	Acknowledgments	I-1
II.	SUMMARY AND CONCLUSIONS	
	Summary	II-1
	Conclusions	II-1
III.	DESCRIPTION OF PROJECT	
	Location	III-1
	Background	III-1
	Pertinent Data	III-1
	Water Quality	III-1
IV.	DESCRIPTION OF THE STUDY AREA	
	Location and Boundaries	IV-1
	Physiography	IV-1
	Climate	IV-1
V.	THE ECONOMY	
	Present	V-1
	Growth Factors	V-4
	Future	V-4

TABLE OF CONTENTS (Continued)

		Page
VI.	WATER REQUIREMENTS	
	General	VI-1
	Municipal Water Use	VI-1
	Industrial Water Use	VI-2
	Agricultural Water Use	VI-2
	Power Generation Water Use	VI-3
VII.	WATER QUALITY CONTROL	
	General	VII-1
	Quality Factors	VII-1
	Streamflow	VII-1
	Stream Loading	VII-2
	Regulated Flow for Quality Control	VII-2
	Special Aspects of Stream Quality Control	VII-3
VIII.	PLANS FOR SUPPLYING FUTURE WATER REQUIREMENTS	
	Ground Water Sources	VIII-1
	Surface Water Sources	VIII-1
IX.	BENEFITS OF STORAGE	
	Evaluation Method	IX-1
	Alternative Plans	IX-1
	Costs	IX-1
	Intangible Benefits	IX-2
X.	BIBLIOGRAPHY	X-1

LIST OF TABLES

		Page
Table III-1.	Chemical Quality in the Sulphur and South Sulphur Rivers--1948-1960	III-2
V-1.	Employment in the Study Area, 1940-1960 . .	V-1
V-2.	Value of Mineral Production-Study Area Total, 1952-1961	V-1
V-3.	Agricultural Statistical Data for Study Area, 1944-1959	V-2
V-4.	Value Added by Manufacturing for Study Area, 1939-1958	V-2
V-5.	Number of Firms by Employment and Type of Manufacturing in the Study Area, 1947, 1954, 1958, 1962	V-3
VI-1.	Municipal Water Requirements	VI-2
VII-1.	Monthly Distribution--Mean Annual Uncontrolled Flow and Mean Monthly Temperatures, Sulphur River Basin, Texas	VII-2
VII-2.	Project Water Quality Control Requirements--2015	VII-3
VIII-1.	Study Area Water Plans--2015 and 2065 . . .	VIII-1
IX-1.	Benefits of Storage in Cooper Reservoir . .	IX-2

LIST OF FIGURES

		Following Page
Figure 1.	Location Map	III-1
2.	Population Trends and Projections	V-5
3.	Natural Annual Discharge Frequency	VII-1

I. INTRODUCTION

Authority

In a letter dated August 8, 1962, the New Orleans District Engineer requested ". . . that your report (June 1961) be reviewed especially with respect to the need for and value of storage required for water quality control in the Cooper project."

This study was made in accordance with: (1) the Water Supply Act of 1958 (Public Law 85-500, Title III) and a Memorandum of Agreement between the Department of the Army and the Department of Health, Education, and Welfare, dated November 4, 1958; and (2) the Federal Water Pollution Control Act (Public Law 84-660) as amended by Public Law 87-88.

Purpose and Scope

This report presents additional recent data and information relevant to the determination of municipal and industrial water supply and quality control requirements to the year 2065 for portions of the six-county area which can be reasonably served by the proposed Cooper Reservoir. The period of study has been extended from 50 to 100 years in accordance with present Corps of Engineer study procedures.

The report also includes an estimate of the annual benefits which could be ascribed to storage allocated to both water supply and flow regulation for quality control.

Acknowledgments

The information and data provided for this review and the original report are greatly appreciated. Among those many persons, firms, and public agencies who have cooperated are the following:

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Texas Department of Health, Austin, Texas
Texas Water Commission, Austin, Texas
Bureau of Business Research, University of Texas, Austin, Texas
Bureau of Economic Geology, University of Texas, Austin, Texas

Sulphur River Municipal Water District
City of Cooper, Texas
City of Commerce, Texas
Chamber of Commerce, Commerce, Texas
City of Sulphur Springs, Texas
Chamber of Commerce, Sulphur Springs, Texas
City of Greenville, Texas
City of Mt. Vernon, Texas
Texas Power and Light Company

II. SUMMARY AND CONCLUSIONS

Summary

1. The site of the proposed Cooper Reservoir is on the South Sulphur River in northeastern Texas near the town of Cooper.

2. The quality of the waters to be impounded is suitable for general municipal and industrial use.

3. Delta, Hopkins, Hunt, and Franklin Counties are considered for water use planning, while due regard is given to the economic, social, and physical factors relating to Lamar and Fannin Counties. These six counties comprise the study area.

4. Existing impounded surface supplies in the vicinity of the project, although of good quality, have small capacities. Ground water supplies in the area have very limited development possibilities and generally are of poor quality.

5. Principal communities in the study area are Paris, Greenville, Bonham, Mt. Vernon, as well as the cities within the jurisdiction of the Sulphur River Municipal Water District--Cooper, Commerce, and Sulphur Springs.

Conclusions

1. Provision of a reliable supply of good quality water will contribute to the rapid development of this area and will consequently serve to stimulate expanding water demands.

2. Local and State authorities are expected to continue action to avoid backwater contamination in the Cooper Reservoir as a result of waste discharge from Commerce.

3. The total 1960 study area population of 127,000 is projected to 300,000 by 2015. Of the 300,000, communities with municipal water supplies are expected to have an aggregate population of 260,000.

CHOCTAW
MC CURTAIN
BRYAN
OKLAHOMA
TEXAS
Lake Texoma
Red River
GRAYSON
FANNIN
LAMAR
PARIS
SHERMAN
HONEY GROVE
RED RIVER
CLARKSVILLE
Sulphur River
DELTA
BOWIE
COLLIN
WOLFE CITY
Cooper Creek
Cooper Res.
TITUS
MC KINNEY
GREENVILLE
SULPHUR SPRINGS
MT VERNON
MT PLEASANT
FRANKLIN
MORRIS
CASS
HUNT
HOPKINS
CAMP
ROCKWALL
GARLAND
RAINS
WOOD
KAUFMAN
DALLAS
SCALE IN MILES
LEGEND
PROPOSED RESERVOIR
EXISTING RESERVOIR
STUDY AREA

BRYAN
CHOCTAW
MC CURTAIN
OKLAHOMA
TEXAS
RED RIVER
FANNIN
LAMAR
DELTA
BOWIE
TITUS
MORRIS
CASS
HUNT
HOPKINS
FRANKLIN
CAMP
WOOD
RAINS
KAUFMAN
PARIS
BONHAM
HONEY GROVE
CLARKSVILLE
GREENVILLE
SULPHUR SPRINGS
MT PLEASANT
DAINGERFIELD
Lake Texarkana
Cooper Res.
Sulphur River
Red River
Cypress Creek
Talco Creek
Cuthand Creek
Pecan Bayou
Sanders Creek
Pine Creek
Caney Creek
Wahoo Creek
Iron Bridge Res.
Sabine Riv
Lavon Res
STUDY AREA
NEW MEX
TEXAS
VICINITY MAP
LEGEND
PROPOSED RESERVOIR
EXISTING RESERVOIR
STUDY AREA
SCALE IN MILES
WATER RESOURCES STUDY
LOCATION MAP

4. Municipalities which may be supplied from the proposed Cooper project are expected to have an aggregate population of 85,000 of the 200,000 and to require 13.6 mgd in 2015.

5. Projected food processing, petroleum, and petrochemical industrial water supply requirements and power generation water needs are expected to total 14.0 mgd in 2015.

6. An average annual flow of 8.4 mgd will be needed to satisfy projected water quality control requirements by 2015.

7. The total study area municipal, industrial, and power water supply needs are expected to reach 199.4 mgd by 2035. A portion of these needs will be met from the proposed Cooper project and the remainder will be met from sources of supply beyond the scope of this study.

8. Municipal, industrial, and water quality control needs will utilize the entire yield of 76.0 mgd from project storage by about 2030. Based upon current treatment technology, an average annual yield of 20.0 mgd from the proposed Cooper Reservoir will be needed for water quality control and 56.0 mgd will serve expected municipal and industrial uses.

9. The total average annual benefit is $244,000, including $184,000 for municipal and industrial water supply and $60,000 for water quality control, based upon the alternative of a single-purpose reservoir at the project site.

III. DESCRIPTION OF PROJECT

Location

The proposed reservoir is located in Delta and Hopkins Counties, Texas, with its dam site at river mile 23.2 on the South Sulphur River (figure 1). The South Sulphur River originates in Fannin County, Texas, and flows in an easterly direction through Hunt County to the reservoir.

Background

The Cooper Reservoir project, South Sulphur River, Texas, was authorized under an act of August 3, 1955, (Public Law 218, 84th Cong., 1st Sess.) substantially in accordance with the construction plans recommended in the report of the Chief of Engineers in House Document No. 498, 83d Congress, 2d Session. The recommendation, in part, provides for a flood control reservoir and makes possible local participation in water conservation storage for municipal and industrial use.[1 2/]

Drainage Area

The average annual runoff at the dam site has been estimated by the Corps of Engineers to be 212,000 acre-feet (190 m.g.d) based upon hydrologic data for the period October 1, 1925, to December 31, 1957, inclusive.[1 2/] The drainage area at the reservoir is 476 square miles.

A storage volume of 115,000 acre-feet for water supply and water quality control purposes has been considered in designing the project. This tentatively selected water supply pool has been reserved for participation by local interest in the project. According to studies made by the Corps of Engineers, this storage will provide a firm yield of about 76 million gallons per day.

Water Quality

The water of the South Sulphur River is of good quality, suitable for general municipal and industrial use. Table III-1 shows selected data from chemical analyses of the Sulphur River at Darden and the South Sulphur River at Cooper.

Table III-1

Chemical Quality in the Sulphur and South Sulphur Rivers--1948-1960 a-c/
(Annual Weighted Average in Parts Per Million)

Water Year Location	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium + Potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids	Hardness as $CaCO_3$ Total	Hardness as $CaCO_3$ Non-carbonate	Percent Sodium
1948 Darden a/	----	27	3.8	21	81	26	22	---	1.9	171	83	17	35
1949 Darden a/	7.3	24	3.5	22	81	20	25	---	1.1	168	74	8	39
1959 Cooper b/	13	32	3.2	21	106	26	14	0.5	3.7	167	93	6	33
1960 Cooper b/	11	28	2.9	17	98	21	9.7	0.4	3.1	143	82	1	31

a/ Darden located on Sulphur River with drainage area of 2,754 square miles.
b/ Cooper located on South Sulphur River with drainage area of 527 square miles.

IV. DESCRIPTION OF THE STUDY AREA

Location and Boundaries

The study area includes six contiguous counties in northeastern Texas as shown in figure 1. Delta, Hopkins, and Hunt Counties lie partially in the South Sulphur River basin and have communities which will utilize water from the Cooper project. Fannin, Franklin, and Lamar Counties have communities which could possibly utilize water from the Cooper project.

The Red River bounds the study area on the north. The western portion is in the East Trinity River basin. The southern portion is in the Sabine River basin. The most easterly point is about 95 miles upstream from Lake Texarkana.

Physiography

The terrain is rolling to hilly. Most of the study area is in the Blackland Prairie Soil Belt. The portions along the Red River and in the southeast are in the Forested Coastal Plain Belt. The clay, black loam, and sandy loam soils of the study area are suitable for the growth of grains, corn, cotton, and truck crops.1/

Climate

The temperature ranges from about 45° in January to about 85° in July with an annual mean of about 65°. The average length of the growing season is on the order of 255 days.2/

The average annual rainfall is about 40 inches throughout the study area.

V. THE ECONOMY

Present

Employment

The increasing importance of employment in manufacturing as compared to that in agriculture can be seen in table V-1.

Table V-1

Employment in the Study Area 2-10/
1940-1960

Year	Agri-culture	Manufac-turing	Other Employed	Total Employed	Un-employed	Total Labor Force
1940	31,203	3,195	22,423	56,821	4,865	61,686
1950	18,029	4,216	28,765	51,809	2,975	55,884
1960	8,882	7,881	27,569	44,312	2,036	46,348

Extractive Industries

Minerals

Petroleum, natural gas, and natural gas liquids production has significant value in the southeastern portion of the study area. There is also some sand, gravel, and clay production. For total annual values, see table V-2.

The high sulphur content in the natural gas liquids has prompted the recent installation of a 200-ton sulphur recovery unit in Franklin County.

Table V-2

Value of Mineral Production-Study Area Total 11-18/
1954-1961

Year	Value*	Year	Value*
1954	25.0	1957	17.6
1955	25.4	1958	21.2
1956	29.2	1959	19.4
1955	24.8	1960	20.7
1956	21.9	1961	19.5

*In millions of constant 1960 dollars.

Agriculture

Agricultural statistics are shown in table V-3. Emphasis has recently shifted to livestock production. Dairy and beef production are the prime livestock activities. Important crops include cotton, corn, grain sorghums, small grains, and forage.

Table V-3

Agricultural Statistical Data for Study Area 16 17/
1944-1954

Year	Value of Farm Products Sold*			No. of Farms	Cropland Harvested (1,000 acres)
	Crops	Livestock	Total		
1944	22,283	11,050	34,333	19,402	920
1949	32,275	10,876	43,051	16,897	869
1954	17,656	13,033	30,691	12,653	788
1959	20,358	26,542	46,900	10,095	861

*Values are in 1,000's of constant 1960 dollars.

Manufacturing

Value added by manufacturing has grown rapidly since 1939 as shown in table V-4. The total number of manufacturing firms has regularly increased.

Table V-4

Value Added by Manufacturing for Study Area 16-17/
1939-1958

Year	Value	Year	Value
1939	10,902	1954	24,915
1947	18,987	1958	30,092

*In 1,000's of constant 1960 dollars.

Manufacturing has been mainly related to clay and wood materials and to farm needs and products in the past. Since 1947, sizable plants for the manufacture of apparel, metal, and machinery products have located in the area, as shown in table V-5. Major food processing and clothing manufacturers have begun site development of plants having ultimate employment levels in excess of 200 since the 1962 Directory of Texas Manufacturers.21/ This demonstrates the continuing vitality of the industrial growth.

Table V-5

Number of Establishments by Employment Size and Type of Manufacturing in the Study Area 20-21/
1947, 1954, 1958, 1962

Type	Number with 1-19 Employees				Number with 20-99 Employees				Number with 100 and Over Employees			
	1947	1954	1958	1962	1947	1954	1958	1962	1947	1954	1958	1962
Food and Kindred Products	35	36	31	29	16	16	17	15	2	2	2	1
Stone, Clay, and Glass Products	5	5	6	8	1	--	2	5	--	--	--	--
Textile Mill Products	--	3	1	1	--	--	1	--	2	1	1	1
Apparel and Related Products	--	1	5	2	7	8	6	7	1	3	6	7
Lumber and Wood Products	6	12	5	1	--	1	2	3	2	1	1	1
Furniture and Fixtures	2	7	5	7	--	1	2	1	1	--	--	--
Printing and Publishing	22	22	20	17	4	4	6	5	--	--	--	1
Pulp and Paper Products	--	1	--	--	--	2	2	1	--	--	--	--
Chemical Products	3	--	3	3	7	5	2	2	--	--	--	--
Petroleum and Coal Products	1	1	--	--	--	--	--	--	--	--	--	--
Rubber and Plastic Products	--	--	--	--	--	--	--	1	--	--	--	--
Leather and Leather Products	--	1	2	2	1	--	--	--	--	1	--	--
Primary Metal Products	1	1	--	--	1	1	--	--	--	--	1	1
Fabricated Metal Products	2	3	5	3	--	--	--	1	--	2	2	2
Machinery, except Electrical	--	5	6	7	--	--	3	2	--	2	1	1
Electrical Machinery	1	--	--	1	--	--	--	1	--	1	2	1
Transportation Products	--	1	6	2	--	--	1	--	--	2	2	2
Miscellaneous Manufactures	2	2	4	2	--	--	--	--	--	--	--	--

The transition toward urbanization is shown on figure 2.22-2/ The principal market centers are Paris, Greenville, Bonham, Mt. Vernon, Cooper, Commerce, and Sulphur Springs.

Growth Factors

1. Far-sighted industrial, agricultural, and general development plans are leaders in virtually every important community.

2. A development potential great in relation to base level activity.

3. Good land and water resources adequate to serve the expanding economy for at least another century and oil and gas reserves adequate for a part of the coming century.

4. Established rail and highway networks and possible access to water transport on either the Red River or Trinity River.

5. Proximity to the Dallas metropolitan area a region which may include portions of the South Sulphur River basin within the next 50 years.

With these factors in mind it is anticipated that this area will come to play a proportionately greater role in providing the goods and services of the nation, as described in the following sections.

Minerals

Petroleum and natural gas liquids extraction is expected to continue at rates comparable to those at present. Sand, gravel, and clay extraction rates will gradually increase to meet local development demands.

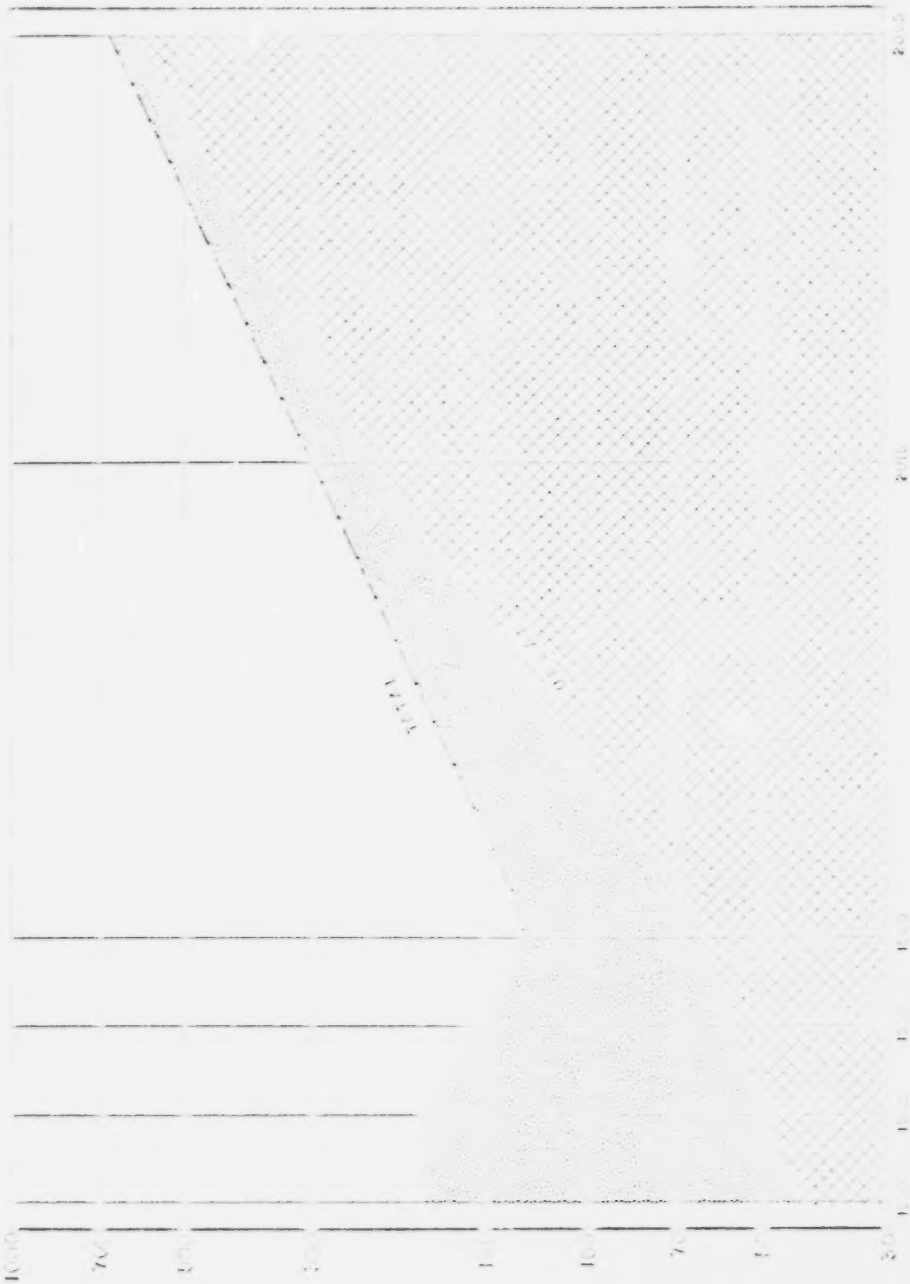
Livestock activity will continue to expand and accelerate increased local forage crop production and livestock related industry. The Dallas metropolitan area will become increasingly dependent upon the area to supply its agricultural needs, especially dairy products.

Crop production will increase to meet the needs of the new large campbell soup plant at Paris which will produce vegetable food and kindred products. Crop production may be increased through the development of supplemental irrigation which is under serious consideration.

Industrial diversification, including petrochemical and petroleum production, is anticipated. Feed and fertilizer demand will expand. Clay, gypsum, and machinery products will form an important segment of the industrial growth.

Urban growth will primarily contribute to the total population increase of the area, as shown in figure 2. The growth rate of the total population is expected to be somewhat greater than that of the Nation and comparable to that of the Southwest.

Principal municipalities will show substantial gains. It is anticipated that a portion of the smaller towns will emerge as important communities, capable of providing municipal water supplies.



VI. WATER REQUIREMENTS

General

Generally, the larger municipal and industrial demands of the area are met from surface supplies and the smaller demands are met from ground water sources or a combination of the two. Presently, there are large existing or proposed surface water impoundment projects in the study area but outside the Sulphur River basin.27/

[illegible]

The cities within the jurisdiction of the Sulphur River Municipal Water District, including Cooper, Commerce, and Sulphur Springs, have immediate interest in the project due, in part, to the following situations:

1. Cooper was obliged to [illegible] the small surface water supply in the dry year of 1963 with the water wells in the North Sulphur alluvium bottoms, which have been since abandoned.[illegible]/

2. The Commerce ground water supply has been developed to its practical maximum and consultants have advised the city to look toward surface supply for future needs.[illegible]/

3. The Soil Conservation Service has estimated a [illegible] percent annual sedimentation rate in [illegible] Lake on White Oak Creek, a major source of supply, for Sulphur Springs.

In 1966, the per capita water requirement in gallons per day averaged 97 in Commerce and 116 in Sulphur Springs. This is considered a representative range for per capita municipal water consumption at present in the study area.

Based upon the [illegible], [illegible], forecasts of future per capita demand in this area, [illegible] gallons per capita day (gpcd) has been selected to estimate the 2015 water requirements for municipally served population.[illegible]/

The total municipal requirement needed to be met from the project in 2015 and 2065 is 13.6 million gallons daily (mgd) and 28.6 mgd, respectively, as shown in table VI-1.

Table VI-1

[illegible]
(mgd)

Year	Cooper Project	Other Sources	Study Area Total
2015	[illegible]	[illegible]	[illegible]
2065	[illegible]	[illegible]	[illegible]

[illegible]

There is presently no significant [illegible] industrial water user [illegible] which might be met from the Cooper project. [illegible] will be supplied from other sources. However, [illegible] food and kindred operations are anticipated in the vicinity of the project.

The growing local market [illegible] coupled with the favorable water supply, will provide the basis for possible local chemical manufacturing. It is anticipated that a basic combination petrochemical and refining operation will be in production by 2015.

The combined industrial needs from the project are 9.0 mgd in 2015 and 15.4 mgd in 2065.

[illegible]

[illegible] irrigation is very limited in the study area. However, [illegible] irrigation [illegible] and ready access to [illegible] from the project. Currently, many interested landowners are cooperating with the Soil Conservation Service to determine the feasibility of project-type irrigation. In the absence of such a project-type arrangement, this report does not anticipate any irrigation within the period of study. If project-type irrigation is provided, certain portions of this report should be reevaluated.

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VIII. WATER QUALITY CONTROL

Introduction

Water quality control is a major objective of water resource development and management. Adequate water quality is necessary to protect fish and wildlife, recreation, agricultural, industrial, domestic and other uses of water. Water quality control is also necessary to protect the quality of water sources which are used for groundwater recharge. Water quality control is necessary to protect existing and potential uses of water.

Water quality control is the regulation of pollutant discharges to water courses so that water quality standards are not violated. Water quality standards are plans for water quality management. Water quality standards consist of designated uses of the water body or segment in question and criteria necessary to protect the uses. Water quality criteria are the specific levels of water quality which, if reached, may render the water body unsuitable for the designated use. Criteria are usually specified as numerical concentrations or narrative statements. Water quality standards are established by the State of Illinois, with the approval of the U.S. Environmental Protection Agency, pursuant to the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500). Water quality standards are subject to review and revision every three years.

Water quality standards are implemented through the National Pollutant Discharge Elimination System (NPDES) permit program. The NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or man-made ditches. Individual households are not included in the NPDES permit program, but other facilities, including commercial establishments, industries, and municipal wastewater treatment plants are included. Each facility that discharges pollutants must obtain a permit that specifies the amount of each pollutant that can be discharged.

Water Quality Conditions

Water quality conditions in the Upper Illinois River Basin are monitored by the Illinois Environmental Protection Agency (IEPA) and the U.S. Geological Survey (USGS). Additional water quality data have been collected by various local governments and agencies in connection with facility planning studies for new or upgraded wastewater treatment facilities. Available water quality data for the Upper Illinois River Basin are summarized in this section.

Dissolved Oxygen

Dissolved oxygen is the most commonly used indicator of water quality conditions in streams. Adequate dissolved oxygen is necessary to support desirable forms of aquatic life. Low dissolved oxygen concentrations are usually caused by the presence of excessive quantities of biochemically oxidizable organic matter in the water. Biochemically oxidizable organic matter is usually measured as biochemical oxygen demand (BOD). Dissolved oxygen concentrations are usually measured directly.

Dissolved oxygen concentrations in streams are affected by a number of factors, including the rate of reaeration from the atmosphere, the rate of photosynthetic production of oxygen by aquatic plants, the rate of biochemical oxygen demand exertion, the rate of nitrification, the rate of benthal demand exertion, and the temperature of the water. Reaeration is the process by which oxygen is transferred from the atmosphere to the water. Photosynthetic production of oxygen occurs during daylight hours when aquatic plants are exposed to sunlight. Biochemical oxygen demand exertion is the process by which biochemically oxidizable organic matter is consumed by bacteria in the water. Nitrification is the process by which ammonia is converted to nitrate. Benthal demand exertion is the consumption of oxygen by bottom deposits. Temperature affects the rate of all of the above processes.

Dissolved oxygen concentrations in streams are usually lowest during the summer months when water temperatures are high and streamflows are low. Under these conditions, the rate of biochemical oxygen demand exertion is relatively high, while the rate of reaeration is relatively low. Dissolved oxygen concentrations usually reach a minimum during the early morning hours, before photosynthetic production of oxygen begins for the day.

Dissolved oxygen concentrations in the Upper Illinois River Basin have been monitored by the IEPA at a number of locations. Data collected at these locations during the summer months of 1977 through 1981 are summarized in Table VIII-1. Dissolved oxygen concentrations in the Upper Illinois River Basin are generally adequate to support desirable forms of aquatic life. Dissolved oxygen concentrations usually exceed the minimum standard of 5.0 mg/l at all locations. Occasional violations of the standard have been recorded at Dresden Island Pool, Marseilles Pool, and Starved Rock Pool.

Biochemical Oxygen Demand

Biochemical oxygen demand is the most commonly used indicator of the presence of biochemically oxidizable organic matter in water. Biochemical oxygen demand is usually measured as the amount of oxygen consumed by bacteria during a 5-day incubation period at 20° C. This parameter is commonly referred to as 5-day biochemical oxygen demand, or BOD5.

Biochemical oxygen demand concentrations usually range from 0.5 to 10.0 mg/l in streams in the Upper Illinois River Basin. Concentrations in excess of 10 mg/l usually indicate the presence of significant quantities of biochemically oxidizable organic matter. Biochemical oxygen demand concentrations in the Upper Illinois River Basin have been monitored by the IEPA at a number of locations. Data collected at these locations during the summer months of 1977 through 1981 are summarized in Table VIII-2. Biochemical oxygen demand concentrations in the Upper Illinois River Basin are generally low. Occasional violations of the standard of 10 mg/l have been recorded at Dresden Island Pool, Marseilles Pool, and Starved Rock Pool.

Nitrogen

Nitrogen concentrations in streams are usually measured as total Kjeldahl nitrogen, nitrate nitrogen, and ammonia nitrogen. Total Kjeldahl nitrogen is the sum of organic nitrogen and ammonia nitrogen. Organic nitrogen is usually measured indirectly by subtracting ammonia nitrogen from total Kjeldahl nitrogen. Nitrate nitrogen is the most highly oxidized form of nitrogen commonly found in water. Ammonia nitrogen is usually found in water as a result of the biochemical oxidation of organic nitrogen. Ammonia nitrogen is also found in water as a result of the reduction of nitrate nitrogen by bacteria under anaerobic conditions.

Nitrogen concentrations in the Upper Illinois River Basin have been monitored by the IEPA at a number of locations. Data collected at these locations during the summer months of 1977 through 1981 are summarized in Table VIII-3. Nitrogen concentrations in the Upper Illinois River Basin are generally low. Occasional violations of the standard of 10 mg/l have been recorded at Dresden Island Pool, Marseilles Pool, and Starved Rock Pool.

Table VIII-1

Monthly Distribution of Annual Precipitation
Average Conditions
Kansas River Basin

Month	Portion of Annual Flow (%)	Average Daily Flow (cfs)
January	2.7	2.0
February	2.5	2.0
March	10.2	8.1
April	13.3	11.0
May	20.1	16.6
June	20.3	16.8
July	8.4	6.9
August	6.4	5.3
September	6.4	5.3
October	4.0	3.3
November	3.2	2.6
December	2.1	1.7

Supplemental [illegible] provide for the [illegible] precipitation. It is assumed that [illegible] compatible to those for [illegible] and [illegible] the year, although [illegible] are limited to the [illegible].

A summary of [illegible] presented in [illegible]. [illegible] year cycle was selected, as [illegible] 10%, and 50-year [illegible] in the [illegible] [illegible] 2015 [illegible] projection [illegible].

At the assumed [illegible] projected [illegible] demands, [illegible] the yield of the project before 2005.

As the various uses become highly competitive for the limited project supply, it is likely that technological innovations in waste treatment will permit quality maintenance with reduced reservoir releases or that other sources of water supply will be developed.

It is anticipated that by the year [illegible], the total of [illegible] mgd for municipal and industrial supplies will evolve a need of [illegible] mgd for water quality control. For the purposes of this report, this combination of requirements has been used to represent the 2015-2065 period.

Table VIII-2

Project Water Quality Control Release Requirements*
(mgd)

Return Period	Maximum Month	Minimum Month	Average Annual
5 year	[illegible]	0	[illegible]
10 year	[illegible]	0	[illegible]
20 year	[illegible]	0	[illegible]

*Based upon present level of adequate treatment.

[illegible]

The provision of storage of water for quality control should be implemented by sound operations and frequently supplemented by other precautions. In the upper Sulphur River basin, the following operations and precautions should be considered.

1. The combined effects of lower natural flows, high temperatures, and high loadings in the summer months necessitate greater releases during this season.

2. The reach below the project will have only a small uncontrolled watershed above it and is expected to require additional flows to maintain a desirable dissolved oxygen level.

3. [illegible] Creek, immediately below [illegible] sewage discharge, will have a relatively low natural runoff and is expected to require supplemental flows for water quality control.

4. To preserve quality in the reach of the [illegible], a short distance downstream from [illegible]'s waste discharge, precautions other than storage for supplemental flow are suggested, as described below.

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VIII. PLANS FOR SUPPLYING FUTURE WATER REQUIREMENTS

Ground Water Supplies

Due to its limited quantity and generally high mineral concentration, ground water in the study area is expected to supply only minor rural needs by 2015.

Surface Water Supplies

All study area municipal and industrial water requirements will be met from surface supplies within the study area in 2015. The Cooper project will supply [illegible] mgd of the [illegible] mgd total study area municipal needs and 9.8 mgd of the 23.6 mgd total study area industrial needs. The project is expected to provide [illegible] mgd for thermal electric power and 8.4 mgd for water quality control. The total 2015 demand upon the project is 36.0 mgd.

By the year 2030, the full yield of [illegible] mgd from the Cooper project will be needed. Assuming treatment providing 90 percent reduction of municipal waste loadings and a steady growth of other uses, quality control needs at that time will be [illegible] mgd and all other uses will require [illegible] mgd from the project. Subsequent demands could be met from other potential sites in the North Sulphur or White Oak basins or by reducing quality control requirements through adoption of more effective treatment techniques. For the purpose of this report, subsequent development is included with other project demand in Table VIII-1.

Table VIII-1

[illegible]
(mgd)

[illegible]	Cooper Project	Other Projects	Total	Cooper Project	Other Projects	Total
Municipal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Industry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Power	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Subtotal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Quality Control	[illegible]	*	*	[illegible]	*	*
Total	36.0	*	*	[illegible]	*	*

*Not within the scope of this study.

III. [illegible]

[illegible]

Section 204 of the Flood Control Act of 1962 authorizes, "preliminary examination, and preliminary investigation, and review of plans for the development of water and related land resources."

Page V-1, par. a, sub. 2 of the above document refers the determination of water quality control benefits through the evaluation of ". . . the cost of achieving the same results by the most likely alternative . . . ."

[illegible]

It "most likely alternative" was the cost of water quality control in a single-purpose reservoir as the project does since the recreation economy is dependent upon water and the project was to be the most economical alternative.

The benefits [illegible] the cost of the "most likely alternative" was to create a storage in other words. These benefits were then [illegible] to the project resulting in the benefit. Since benefits is an unknown the cost of the alternative [illegible].

[illegible]

The purpose of [illegible] was to [illegible] from the cost [illegible] of [illegible] the [illegible] benefits [illegible] and [illegible] were made [illegible] annually [illegible] and [illegible] 50 years of use. This period of use [illegible] annually to provide [illegible] the interest during the second 50-year period [illegible] 4 1/8 percent.

Table [illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]